

Attorney's Docket No.: 042390.P13718

Patent

UNITED STATES PATENT APPLICATION

For

**ELECTRONIC ASSEMBLY HAVING COMPOSITE ELECTRONIC
CONTACTS FOR ATTACHING A PACKAGE SUBSTRATE TO A
PRINTED CIRCUIT BOARD**

Inventors:

Edward L. Martin

L. Todd Biggs

Prepared by:

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP
12400 Wilshire Boulevard
Los Angeles, CA 90025-1026
(408) 720-8300

Attorney Docket No.: 042390.P13718

"Express Mail" mailing label number: EL 867552308 US

Date of Deposit: February 4, 2002

I hereby certify that I am causing this paper or fee to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated above and that this paper or fee has been addressed to the Assistant Commissioner for Patents, Washington, D.C., 20231.

Linda K. Brost

(Typed or printed name of person mailing paper or fee)

Linda K. Brost
(Signature of person mailing paper or fee)

February 4, 2002
(Date signed)

ELECTRONIC ASSEMBLY HAVING COMPOSITE ELECTRONIC CONTACTS FOR ATTACHING A PACKAGE SUBSTRATE TO A PRINTED CIRCUIT BOARD

BACKGROUND OF THE INVENTION

1). Field of the Invention

[0001] This invention relates to an electronic assembly of the kind having a semiconductor package substrate which is attached to a printed circuit board.

2). Discussion of Related Art

[0002] A semiconductor die having an integrated circuit formed therein is often mounted on top of a package substrate. The integrated circuit is electrically connected through contact pads on an upper surface of the package substrate and metal lines in the package substrate to contact pads on the lower surface of the package substrate. A respective solder ball is attached to a respective one of the contact pads on the lower surface of the package substrate. The solder balls are located in an array in a horizontal plane.

[0003] The solder balls are subsequently located on contact terminals on an upper surface of a printed circuit board. The solder balls are then heated to above their melting temperature, so that they reflow over the contact terminals on the printed circuit board. Subsequent cooling and solidification of the solder

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The invention is described by way of examples with reference to the accompanying drawings, wherein:

[0006] Figure 1 is a side view illustrating an electronic assembly which is assembled according to the principles of the invention;

[0007] Figure 2 is a side view illustrating electronic contacts located on a jig prior to attachment to contact pads on a package substrate;

[0008] Figure 3 is a view similar to Figure 2 after the electronic contacts are brought into contact with the contact pads and the partial assembly is flipped so that the electronic contacts are at the top;

[0009] Figure 4 is a view similar to Figure 3 after heating, cooling, and removing of flux;

[0010] Figure 5 is a view similar to Figure 4 after the assembly of Figure 4 is flipped so that the electronic contacts are at the bottom, and subsequently located on contact terminals of a board assembly; and

[0011] Figure 6 is a view similar to Figure 5 illustrating the electronic assembly of Figure 5 after heating and cooling to attach attachment layers of the electronic contacts to the contact terminals while spherical cores of the electronic contacts serve as standoffs to control movement of the package substrate toward to the board assembly.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Figure 1 of the accompanying drawings illustrates an electronic assembly 10 constructed according to the principles of the invention. The manner in which the electronic assembly 10 is constructed is now further described with reference to Figures 2 through 6.

[0013] Figure 2 illustrates components of a partially constructed semiconductor assembly 12, together with a contact holding jig 14. The semiconductor assembly 12 includes a substrate subassembly 16, a semiconductor die subassembly 18, and electronic contacts 20.

[0014] The substrate subassembly 16 includes a package substrate 22, and a plurality of contact pads 24 on a lower surface of the package substrate 22. The package substrate 22 is a multilayer substrate, including alternating dielectric and metal lines (not shown). The contact pads 24 are made of metal, and are electrically connected to the metal lines. More contact pads (not shown) are formed on an upper surface of the package substrate 22. The contact pads on the upper surface of the package substrate 22 are also in electric communication with the metal lines, and through the metal lines with the contact pads 24.

[0015] The semiconductor die subassembly 18 includes a semiconductor die 26 and a plurality of electronic connections 28. The die 26 has an integrated circuit (not shown) formed in a lower surface thereof, and the electronic connections 28

are formed on terminals (not shown) on a lower surface of the integrated circuit. The electronic connections 28 are located on upper surfaces of the contact pads on the upper surface of the package substrate 22, and subsequently soldered to the contact pads in a thermal reflow process. The die 26 is thereby structurally secured through the electronic connections 28 to the package substrate 22. The contact pads 24 are also in electric communication through the metal lines in the package substrate 22 and the electronic connections 28 with the integrated circuit of the die 26.

[0016] Each electronic contact 20 has a spherical core 32 and an attachment layer 34 entirely surrounding the spherical core 32, i.e., uniformly located on all surfaces of the spherical core 32. In the preferred embodiment, the spherical core 32 is made of pure copper, and has a diameter of approximately 0.7 mm. In the preferred embodiment, the attachment layer 34 is made of a pure eutectic of tin and silver, comprising 3.5% silver by weight, and has a thickness of approximately 0.025 mm. Such electronic contacts may be obtained from Sumitomo Special Metals Co. Ltd. of Osaka, Japan.

[0017] Recesses 36 are formed in an upper surface of the jig 14. The recesses 36 are aligned with the contact pads 24, and a respective one of the electronic contacts 20 is located in a respective one of the recesses 36. Each electronic contact 20 is thereby aligned directly below a respective one of the contact pads 24.

[0018] The contact pads 24 have lower surfaces that are selectively stencil-printed with a solder flux 38. The jig 14 is subsequently moved vertically upward in a direction 40. The electronic contacts 20 move together with the jig 14 in the direction 40, and penetrate the solder flux 38.

[0019] After the electronic contacts 20 and the contact pads 24 are brought together, the entire assembly is flipped so that the jig 14 is at the top. The jig 14 is then elevated to leave the electronic contacts 20 on the contact pads 24. Figure 3 illustrates the semiconductor assembly 12 after the jig 14 is elevated. The viscous nature of the solder flux 38 prevents the electronic contacts 20 from rolling off the contact pads 24.

[0020] Figure 4 illustrates the semiconductor assembly 12 of Figure 3 after being heated, and subsequently cooled, and after removal of the flux 38. The semiconductor assembly 12 is heated to a temperature of approximately 230° C. The material of the layers 34 melts at approximately 227° C. The layers 34 wet over the contact pads 24. The spherical cores 32, being made of copper having a melting temperature of 1083° C, do not melt. Subsequent cooling of the semiconductor assembly 12 to below the melting temperature of the material of the layers 34 attaches the layers 34 to the contact pads 24.

[0021] As shown in Figure 5, the semiconductor assembly 12 is subsequently flipped so that the electronic contacts 20 are at the bottom, and located on top of a board assembly 42. The board assembly 42 includes a printed circuit board 44

and contact terminals 46 formed on an upper surface of the printed circuit board 44. A flux 47 is stencil-printed on each contact terminal 46. A lower portion of each layer 34 penetrates the flux 47 and is located on a respective one of the contact terminals 46.

[0022] The partially manufactured electronic assembly 48 of Figure 5 is then again heated to approximately 230° C, and cooled to room temperature. Figure 6 illustrates the electronic assembly 48 after being heated and cooled. The temperature of 230° C again melts the material of the layers 34, so that they wet over the contact terminals 46.

[0023] Melting of the layers 34 also causes a small amount of movement or “collapsing” of the package substrate 22 and the die 26 in a direction 50 toward the printed circuit board 44. The spherical cores 32 do not melt at the temperature of 230° C. The spherical cores 32 thus maintain their spherical shape throughout the reflow process, and act as standoffs that limit movement in a direction 50 until each spherical core 32 contacts a contact pad 24 and a contact terminal 46 on opposing sides thereof. The spherical cores 32 disallow further movement of the package substrate 22 in a direction 50 toward the printed circuit board 44. The remaining distance between opposing ones of the contact pads 24 and contact terminals 46 is thus limited by the diameter of the spherical core 32. Subsequent cooling of the electronic assembly 48 solidifies the attachment layers 34, and thereby secures them to the contact terminals 46 and the contact pads 24.

[0024] Each contact terminal 46 is secured to a respective contact pad 24 via a respective one of the layers 34. The contact terminal 46 is also electrically connected to the contact pad 24 via both the attachment layer 34 and the spherical core 32.

[0025] Referring again to Figure 1, capacitors 52 are attached to the lower surface of the package substrate 22. The capacitors 52 are entirely surrounded by the electronic contacts 20. Each capacitor 52 has a lower surface which is spaced from the lower surface of the top of the package substrate 22 by a distance which is smaller than the spacing between the lower surface of the package substrate 22 and the upper surface of the printed circuit board 44. As such, a gap 54 is defined between a lower surface of each capacitor 52 and the upper surface of the printed circuit board 44. Contact between the capacitors 52 and the printed circuit board 44 is prevented by the spherical cores 32.

[0026] The diameter of the spherical cores 32 depends largely on the height of the capacitors 52. In other embodiments, the diameter of the spherical cores 32 may be between 0.5 and 0.8 mm. In other embodiments, the attachment layers 34 may be between 0.015 and 0.035 mm thick.

[0027] In another embodiment, a eutectic of tin and copper with 0.7% copper by weight may be used instead of the tin and silver eutectic of the layers 34. A tin and copper eutectic, however, has a melting temperature of 232° C, which is slightly higher than that of the tin and silver eutectic. The tin and silver eutectic

is thus preferred over the tin and copper eutectic.

[0028] Another eutectic that may be used instead of the tin and silver eutectic of the layers 34 is a tin and lead eutectic, with 37% lead by weight. Such a tin and lead eutectic has a relatively low melting temperature of approximately 183° C. The disadvantage of such a eutectic is that it contains lead, which is environmentally undesirable. Alternatively, it may be possible to use pure tin for the attachment layer, but pure tin has a relatively high melting temperature.

[0029] Instead of copper, the spherical cores 32 may alternatively be made of silver. Coated silver spheres can be obtained from Seju Metal Industry Co. Ltd. in Tochigi, Japan. Silver is, however, toxic, and expensive when compared to copper. (The small amount of silver in the eutectic of the layers 34 is inconsequential.)

[0030] The spherical cores 32 may alternatively be made of a polymer. Polymer spheres can be obtained from Sekisui Chemical Co. Ltd. in Osaka, Japan. In the case of polymer spheres, the attachment layer 34 will provide the entire electric connection between the contact pads 24 and the contact terminals 46.

[0031] Aluminum or bronze may also be used as an alternative to copper for the spherical cores, although it may be difficult to form attachment layers on aluminum or bronze.

[0032] In all other embodiments, there is preferably at least a 30° C temperature difference in melting temperatures of the cores and the attachment layers.

[0033] In the embodiment described, a jig is used to locate the contacts 20 shown in Figure 2, and the assembly is then flipped as shown in Figure 3.

Another embodiment may use a vacuum chuck at the top to which contacts are held by a vacuum seal on the back. The contacts may then be dipped in flux. The vacuum chuck then moves the contacts into contact with a package substrate below.

[0034] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative and not restrictive of the current invention, and that this invention is not restricted to the specific constructions and arrangements shown and described since modifications may occur to those ordinarily skilled in the art.